

On the Biology and Economic Significance of the Chalcid Parasites of Australian Sheep Maggot-flies.

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(Plates IX. and X.)

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SHEEP maggot-flies are amongst the commonest and most widely spread insects in Australia. When one takes into consideration the extensive degree of parasitism exhibited by Hymenoptera upon other insects, it might reasonably be expected that numerous species would be found which depend for their existence on this abundant food supply. A number of such wasps have actually been discovered in Australia, mainly by Mr. W. W. Froggatt, of Sydney. In the present paper three other primary parasites of sheep blowflies are recorded. Careful search would, no doubt, reveal the presence of other species.

The forms hitherto recorded are—(1) *Nasonia brevirornis* Ashmead; (2) *Dirhinus sarcophagæ* Froggatt; (3) *Chalcis calliphoræ* Froggatt; (4) *Hemileiomyia abrupta* Dodd. The following forms in addition to Nos. 1, 2, and 3 have been found parasitizing either the larvæ or the pupæ of blowflies in Brisbane under natural conditions:—(5) *Spalangia muscidarum* Richardson; (6) an Encyrtid wasp, for which the name *Australencyrtus giraulti*, n. gen., n. sp., is proposed; (7) and a Proctotrypid (Diapriid) wasp, apparently also new, for which we propose the name *Paraspilomicrus froggatti*, n. gen., n. sp. (8) An eighth species, *Pachycrepoideus dubius* Ashmead, has been recorded by Girault from North Queensland, where no doubt it parasitizes Muscoid flies, as elsewhere. (9) Probably *Chalcis dipterophaga* Girault & Dodd is a parasite of blowflies.

In the present paper we give (A) an account of the biology of some of these forms, together with some general remarks on each species; (B) a discussion of the rôle they can be made to play in the control of the sheep flies; (C) a description of two apparently new wasp parasites of Australian blowflies.

Some information relating to these hymenopterous parasites of flies has been recently published by one of us (Johnston, 1921).

A.—OBSERVATIONS ON THE BIOLOGY OF THE CHALCID PARASITES OF AUSTRALIAN SHEEP BLOWFLIES.

The chalcid wasps that parasitize sheep maggot-flies may be divided into two groups according as they attack the pupa or larva. Egg parasites have not yet been discovered. To the former group belong *Nasonia brevicornis*, *Paraspilomicrus froggatti*, *Spalangia muscidarum*, *Dirhinus sarcophagæ*, *Pachycrepoideus dubius*, and *Hemilexomyia abrupta*; to the latter group, *Chalcis dipterophaga*, *Chalcis calliphoræ*, and *Australencyrtus giraulti*.

1. *Nasonia brevicornis* Ashmead. (Figs. 5, 6, 7, 20, 21, 22, 27-33.)

A full description of this species was given by Girault and Sanders (1909-1910). Its presence in Australia was detected by Girault in October, 1911; two years later it was found by Mr. Froggatt in N.S.W. and by Mr. E. Jarvis in Longreach, Central Queensland.

The wasp occurs very commonly in Brisbane, and can generally be easily attracted by exposing decaying meat. Careful observations on its life-history have been carried out by W. W. Froggatt and T. McCarthy (1914, 1915), as well as by J. L. Froggatt (1919). A more complete account which includes the observations of these authors has been given by Altson (1920). Graham-Smith (1919) also refers to this insect in his work on the parasites of common house-flies. (*See also* Johnston and Baneroft, 1920; Johnston, 1920.)

In the following account, therefore, only a very brief summary of published observations, supplemented by others of our own, will be given.

Length of Life-cycle.—Various observers have obtained varying results; Girault and Sanders give 15-22½ days, according to the season, in America; W. W. Froggatt and McCarthy 11 to 15, and J. L. Froggatt gives 11-14 days, in N.S.W. In Brisbane, during November, the total period was found by us to vary from 11 to 14 or even as much as 16 days, while in January and February it occupied about 14 days. Altson found that under laboratory conditions with a mean temperature of 20° C. it averaged 21 days in London.

Oviposition.—The wasps are readily attracted to carrion,

and are frequently seen sitting on the breeding-jars, or walking over the soil in search of pupæ. When a suitable pupa is found the wasp walks over it, testing the shell with its antennæ, and when a favourable spot has been found inserts its ovipositor (figs. 5, 6, 7), taking up the curious attitudes that have been described by various workers. During the process of piercing the pupal shell an oily fluid is seen running down the ovipositor, evidently acting as a lubricant. During oviposition, which lasts from a few minutes to a quarter of an hour (or even 25 minutes, Froggatt and McCarthy; 30 minutes, Altson), a number of eggs, generally about 15 to 20, but sometimes only one or two, are deposited on the surface of the developing fly (fig. 29). On several occasions it was observed that, although the ovipositor had been inserted for quite a long time, no eggs were deposited. The ovipositor is a moderately long structure, and, as it is inserted to its full length, the wasp places the eggs in clusters, sometimes at a considerable distance from the puncture.

Egg (fig. 27).—The egg is whitish and somewhat transparent, measuring, when freshly laid, about .32 mm. in length by .08 to .12 mm. in breadth. It appears to contain a small amount of yolk. During development the egg frequently lengthens a little. The duration of the egg period is exceedingly important economically (as will be described more fully below), and, according to published observations, varies from 30 to 74 hours. The time in Brisbane in midsummer was found to be 40 hours.

Larva.—This, on hatching, is a small whitish maggot about .3 mm. long, which maintains the same general appearance throughout larval life. The larvæ do not appear to move far from their original source of attachment, but can be seen clustered together where the eggs were originally placed (fig. 20). Here they appear to remain throughout the feeding period, which is about $4\frac{1}{2}$ to 5 days (7 to 10 in London, Altson). The three instars are easily recognisable by the structure of the jaws, which in the first instar are long, slender, slightly curved, stylet-like structures, serving to penetrate the epidermis of the developing fly (fig. 30). The larva of the second instar is much larger than that in the first stage (fig. 31); the jaws are more powerful, and the whole larva appears much more heavily chitinised (fig. 32). The jaws of the larva

in its third instar are quite different, being much sharper piercing structures, transversely arranged (fig. 33). The fully grown larva varies in length from 1.3 to 2.4 mm.

Feeding takes place by the suetorial action of the mouth applied to the original puncture. Two sets of larval muscles appear to take part in this, a sphincter set surrounding the end of the head and evidently serving to protrude the pharynx, and a retractor set inserted into the pharynx and serving to withdraw it (fig. 32). During the feeding stage the intestine remains closed distally. The larva then undergoes a resting period (propupal stage) at the end of which it empties the intestine, the larva (fig. 21) changing from dirty grey to pure white. After about 22 hours it moults, and a whitish pupa appears, about $1\frac{1}{2}$ mm. in length (fig. 22). About two days later the eyes turn reddish, on the next day they are bright red; on the following day the anterior half of the pupa turns black, and on the last day the mature wasp may be seen, within the pupal skin. The whole pupal period lasts about six days in Brisbane (five in N.S.W. according to Froggatt and McCarthy). Altson states that in London the period of development of the larva occupies 7 to 10 days from the time of hatching, with a propupal stage of 1 to 3 days, the pupal stage being 8 to 12 days (1920, pp. 219, 220). Girault and Sanders give 9 days as an average (U.S.A., springtime).

The males generally hatch first and can be seen on or near the fly-pupa, waiting for the females to emerge. Fertilisation takes place immediately, and in about six hours (3 to 24, Girault and Sanders) the females are ready for laying. Unfertilised females also oviposit quite readily, the offspring being entirely males. The females will oviposit for about three weeks. Observations by Girault and Sanders and by Froggatt and McCarthy show that on an average one female may deposit 113 eggs, but unfortunately she distributes them only amongst 17 to 20 pupæ (on an average) so that her destructive action is considerably limited. The wasp thrives fairly well in the Australian climate, and has established itself over wide areas of N.S.W. and Queensland. Froggatt and McCarthy (1914) mentioned the following blowflies as hosts:—*Calliphora villosa* (= *Neopollenia stygia*), *C. oceanica* (= *Paracalliphora augur*), *C. erythrocephala*, and *C. rufifacies*. J. L. Froggatt (1919) added to the list *Lucilia sericata*, *Sarcophaga aurifrons*, *Ophyra nigra*, and *Pycnosoma varipes*, the last-named two being

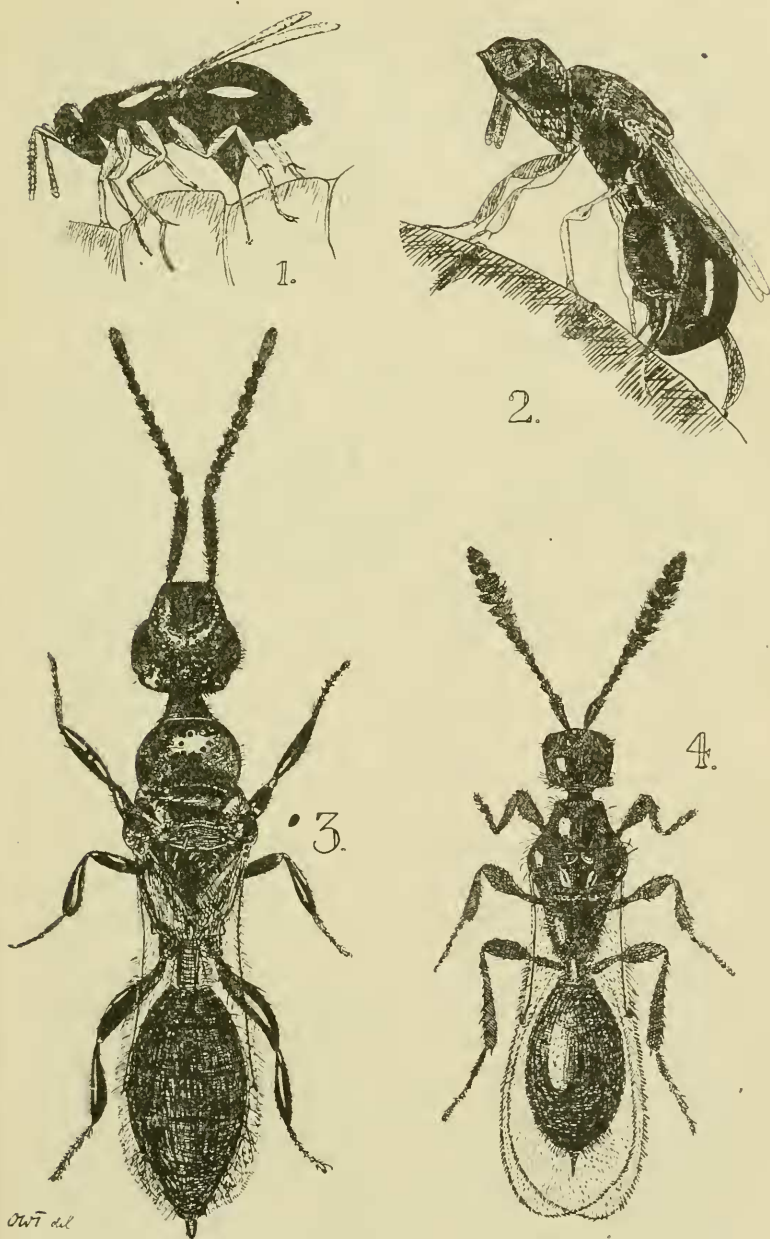


Fig. 1, *Australencyrtus giraulti* ovipositing in maggot : 2, *Dirhinus sarcophagæ* ovipositing in pupa : 3, *Spalangia muscidarum* (from Burnett River) ; 4, *Paraspilomierus froggatti*.

less readily selected by the chalcid for parasitism than the others mentioned. Johnston and Bancroft (1920) added *Musca domestica*, *M. vetustissima*, *M. hilli*, and *M. terræ-reginæ*. Altson (1920) gives a list of British hosts. No less than eight species of flies (*Musca domestica* and seven blowflies) are mentioned by Girault and Sanders as capable of becoming parasitized by *Nasonia*.¹ We have found the wasp able to parasitize, in addition, the pupæ of the various species of *Sarcophaga* recently described by us as breeding in carrion (*S. aurifrons*, *S. impatiens*, *S. irrequieta*, *S. misera*, etc.)

2. *Paraspilomicrus froggatti* Johnston and Tiegs.

(Figs. 4, 7, 8, 18, 19.)

This Proctotrypid was first obtained from naturally infected *Lucilia* pupæ in November, 1920. A number of wasps (eight altogether) were bred from a single pupa.

Fertilisation takes place soon after hatching. The male sits upon the female, the long antennæ intertwining and undergoing a short vibration every few seconds, producing a most ludicrous effect. During oviposition the wasp adopts a curious arched attitude (fig. 8), the egg-laying process lasting about ten minutes. No developmental stages have been observed by us.

This wasp was seen around Brisbane in October and November, 1920, and again in April, 1921, but never commonly. A description of this apparently new genus and species is given at the end of this paper.

3. *Spalangia muscidarum* Richardson. (Fig. 3.)

This wasp was first recorded from Australia by Johnston and Bancroft (1920), who found it parasitizing various flies (*Musca* spp. and *Stomoxys calcitrans*) in Eidsvold, Burnett River, Queensland. They stated that in captivity females would parasitize *Pycnosoma ruffacies*, *P. varipes*, *Paracalliphora augur*, *Chrysomyia dux*, *Sarcophaga* spp., as well as other sheep and carrion flies. We have also seen a number of these wasps bred from *Lucilia* pupæ from Roma, by Mr. F. Taylor; also some in the U.S. National Museum, Washington, bred from *Musca domestica* in Adelaide and forwarded by Mr. A. M. Lea. During February this wasp appeared attacking the large golden species of *Sarcophaga* (*S. impatiens*, etc.) in Brisbane. It is, then, one of the natural enemies of sheep maggot-flies.

¹ A paper dealing with the biology of *N. brevicarius* has been published by E. Roubaud (Bull. Sci. France and Belgique 1917, pp. 425-439—abstract in Rev. Appl. Ent., B, 5, 1917, pp. 157-9).

The total period from egg deposition to the emergence of the wasp was 21 to 28 days during midsummer, and never more than one wasp developed from a single pupa (Johnston and Baneroft, 1920). With *Sarcophaga impatiens* during February the period varied considerably, being between 23 and 30 days; and no more than one wasp appeared from even these large pupæ.

This chalcid appears to be widely distributed over Southern Queensland, though probably not common.

4. *Dirhinus sarcophagæ* Froggatt. (Figs. 2, 10, 23, 24, 34.)

This wasp was first described and figured by Froggatt (1919), who bred it from pupæ of *Sarcophaga aurifrons* Macq. It occurs also in Brisbane and is most common about February. It will parasitize any of the common sheep-fly pupæ, *Pycnosoma* (both species), *Lucilia* spp., and *Sarcophaga* spp. being readily attacked. During oviposition the wasp assumes a most remarkable, uncouth attitude (fig. 2), remaining in this position for about fifteen minutes, and seems oblivious to everything going on around it, so that the pupa with the parasitizing wasp can readily be lifted without disturbing the latter. After oviposition is completed the wasp settles on the pupa in a crouching attitude for a long time, and then wanders off, usually to attack another.

The egg measures .68 mm in length and .17 in breadth (fig. 34). The egg period has not been observed. The maggot is a large whitish legless creature (fig. 23; Froggatt, 1919, p. 854, fig. 1) which feeds on the outside of the fly-nymph just as *Nasonia* does. It measure from 3 to 4 mm. in length.

The third instar does not appear to possess jaws. Its head is a curious structure and is provided with two prominent lips (fig. 10), the action of which causes the liquid contents of the disintegrating fly larva to flow into the mouth. The larvæ appear to be predaceous; for on several occasions two larvæ were found within a fly-pupa, yet not more than one wasp was observed to emerge from each fly-pupa. The wasp-pupa is a large white creature (fig. 24), with the characteristic *Dirhinus* appearance. The pupal period has not been determined but it is more than 7 days. The total period from oviposition to emergence during November, 1920, was found to be 25 days; but during January, 1921, as much as 28 days.

Mr. Froggatt regards this wasp as being capable of digging well beneath the soil in search of *Sarcophaga* pupæ. This is probably not the case. Sarcophagid flies pupate just as frequently on the surface of the soil as do the other carrion-flies, and it is doubtful whether the wasp would trouble to attack those beneath the surface of the soil, when there are more accessible pupæ available. On one occasion this alleged habit was tested. Soil containing pupated larvæ was put into a bottle, together with a female *Dirhinus*; she could easily have reached them by a little digging (the soil being about one inch in depth), but took no notice whatever of the buried pupæ, and after a few hours' captivity spent all her time in trying to escape.

5. *Pachycrepoideus dubius* Ashmead.

This wasp was first described from U.S.A., where it parasitizes the house-fly. It has been recorded by Girault from Northern Queensland, but nothing further is known about it in this country. Undoubtedly it attacks various flies occurring in that locality.

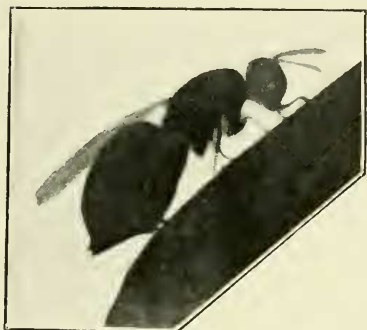
6. *Hemilexomyia abrupta* Dodd.

This Diapriid wasp was first described and figured by W. W. and J. L. Froggatt (1917, pp. 32-33) as being bred from a blowfly (? *Ophyra nigra*), and from *Musca domestica* (1918, p. 18) near Hay, N.S.W. It was more fully described and named by Dodd (1920, p. 421) under the above designation. The latter author reported it as a parasite of *Ophyra nigra* and *Calliphora villosa* (i.e. *Neopollenia stygia*) in N.S.W. (Froggatt collection). It has not been found in Brisbane.

7. *Chalcis calliphoræ* Froggatt.²

This fairly large insect was described by Froggatt (1916, p. 506; 1917, p. 30) from Hay district, N.S.W., as a black wasp about the size of a small housefly, with reddish-yellow antennæ, oval shining red-brown abdomen, and with thickened hind femora. This chalcid, which breeds readily in captivity, attacks blowfly larvæ and does not prevent their pupation before destruction occurs.

² D. Miller (N. Z. Jour. Agric., 22 June, 1921) states that large numbers of this parasite, obtained from Australia, were liberated in New Zealand two years ago, but that no definite results have yet been attained.



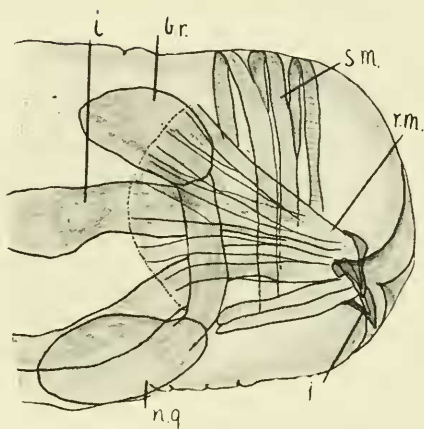
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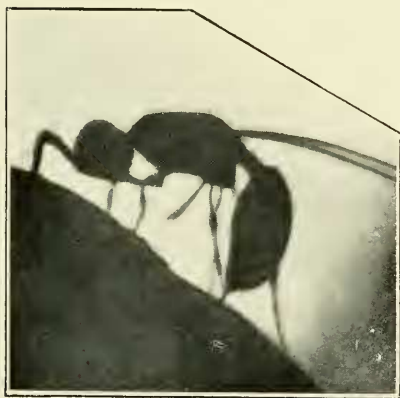
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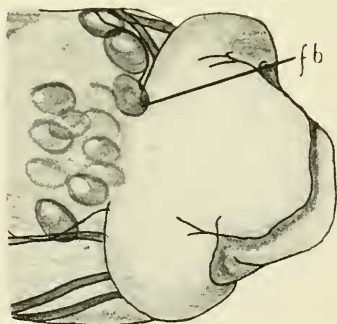
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8.



10.

Figs. 5-7, stages in oviposition (*Nasonia brevicornis*). 5, commencement of insertion of ovipositor; 6, ovipositor fully inserted; 7, oviposition completed, wasp licking up fluid from puncture; 8, *Paraspilomicrus* ovipositing in pupa; 9, head of larva of *Austr. giraulti*, showing suctorial apparatus, etc. (*s.m.*, sphincter muscle; *r.m.*, retractor musculature; *i.*, intestine; *br.*, brain; *n.g.*, first nerve ganglion; *j.*, jaw); 10, head of larva of *Dirhinus sarcophagæ* (*f.b.*, fat body).

8. *Chalcis dipterophaga* Girault and Dodd.

Syn. : *C. calliphoræ* Johnston 1921 (from Brisbane).

This rather large wasp, which seems to differ from *C. calliphoræ* only in the lighter colouration of the antennæ and abdomen, was found on one occasion in Brisbane to be attracted to blowfly maggots. There is little doubt that the species is a parasite of the latter. Girault (1915) reported that this Chalcid was bred from dipterous puparia in North Queensland.

9. *Australencyrtus giraulti* Johnston and Tiegs.

(Figs. 1, 9, 11-17, 25-26.)

This Encyrtid wasp, of which a description is given at the end of the paper, was first discovered attacking sheepfly maggots in Brisbane in October, 1920. It was soon found that it could be bred with comparative ease and in large numbers. On one occasion many thousand individuals were obtained after several generations from a single female. During February, 1921, the wasp was again seen in the open, while during April it was quite common around decaying meat. A few specimens were seen during July, 1921.

The female attacks all the common sheep blowflies in their larval state, seeming to prefer smooth maggots (*Chrysomyia dux*, *Lucilia* spp., *Paracalliphora augur*), but will quite readily attack the "hairy" *Pycnosoma* larvæ (*P. rufifacies* and *P. varipes*) as well as those of the thick-skinned *Sarcophaga* spp. The wasps are exceedingly active, especially the females, which settle on any part of the maggots (fig. 1), and immediately begin to oviposit after showing great dexterity in clinging to the maggot as the latter crawls or wriggles. As a rule they do not appear to hurt the maggot in any way during the operation, though sometimes the latter is seen to writhe a little, no doubt when the ovipositor happens to injure a nerve.

Under artificial conditions numerous wasps commonly attack a maggot at once. When some decaying meat is exposed these wasps can often be seen close to the living maggots, and they will even attempt to parasitize those which are wriggling about immediately beneath the soil. Oviposition lasts from a quarter to half a minute, but at times when the maggot is quiet it will take considerably longer. Usually about seven eggs appear to be laid at each act of oviposition. Sometimes as many as twenty-nine wasps emerge from a pupa (artificially infected, probably by several wasps), the insects

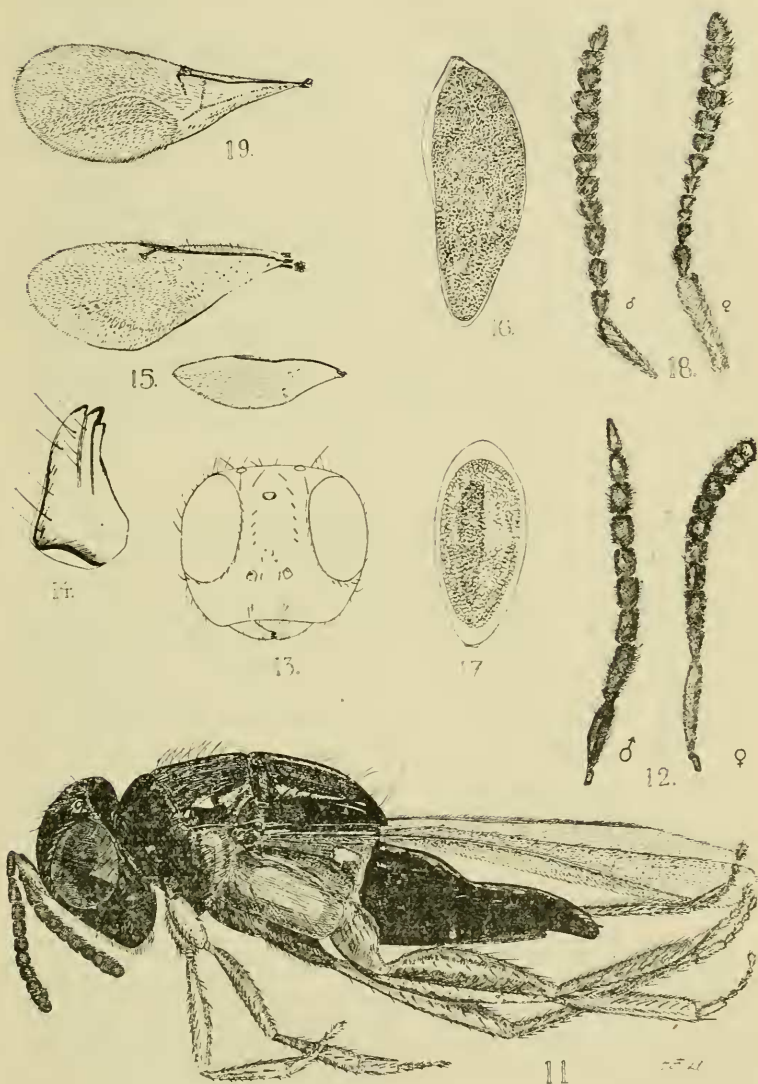
being then considerably smaller than usual. If pupæ be too heavily parasitized, then neither wasps nor flies emerge. The following numbers were obtained from six artificially infected fly-pupæ, kept under observation : 29, 26, 22, 14, 11, 10.

The freshly laid egg is rather long and somewhat irregularly shaped, measuring .208 mm. in length and .076 mm. in breadth. A small clear area can be seen at one end of the otherwise granular protoplasm ; and it is here that the egg membrane possesses a micropyle (fig. 16). The egg soon begins to segment by the usual peripheral segmentation method characteristic of insects. After 24 hours it is in a high state of segmentation and the developing embryo can be seen in the middle (fig. 17). The egg has by this time contracted considerably, measuring only .164 mm. in length by .072 mm. in breadth. Hatching appears to take place in about 48 hours, but this statement is made with considerable reserve.

The larva is of the usual 14-segmented type, the nine spiracles together with the tracheæ being very evident (fig. 25). Feeding appears to take place much in the same way as in *Nasonia*, that is, by a suctorial action produced by the alternate action of protrusive (sphincter) and retractile buccal muscles (fig. 9). A pair of chitinous jaws, resembling those of the third instar of *Nasonia*, are present. The midgut does not communicate with the rectum until the end of the feeding stage, when, probably after a period of resting, defæcation takes place, and then after about one day the larva moults and a pupa appears (fig. 26).

The pupa is at first white in colour ; after a few days the eyes redden and then the whole pupa darkens and gradually develops into the adult. The full period, from oviposition to emergence of the adult, occupies about 20 days in midsummer. In October it was found to be 25 days, in February 21, in May as much as 28 or even 30 days, the time gradually lengthening between February and May as the weather became cooler. In June and July it occupied approximately six weeks.

It was found that when wasps which had just emerged from the fly-pupa were isolated they would parasitize maggots as usual, and further that the offspring consisted of males and females in the normal proportion, which we have ascertained to be about 3 : 7. It must, therefore, be inferred that



Figs. 11-17, *Australencyrtus giraulti*. 11, adult female ; 12, antennæ of male and female ; 13, head, face-view ; 14, mandible ; 15, wings of female ; 16, freshly deposited egg, taken from larva of *Sarcophaga* ; 17, egg 24 hours old.

Figs. 18, 19, *Paraspilomicrus froggatti*. 18, antennæ of male and female ; 19, fore wing.

fertilisation actually took place before the wasps had emerged from the fly puparium. If this method alone took place in nature then the only opportunity for true interbreeding instead of inbreeding would occur when two females chanced to parasitize the same maggot. Copulation has been observed to take place immediately after emergence, the act occupying about a quarter of a minute.

The wasp is an exceedingly active little creature, and is easily distinguished from *Nasonia* by the brown colour of the under side, as well as by its much greater activity often manifested by leaping movements. It does not appear to live very well in close captivity, where our method adopted in keeping them has been merely to place them in glass tubes and provide them with a little diluted honey. Under these conditions they began to die on about the third day, and we have not kept them alive longer than seven days.

B.—THE ECONOMIC SIGNIFICANCE OF THESE CHALCID PARASITES.

The extent to which a species of parasite is capable of destroying or checking the numbers of its host species depends on numerous factors, all of which must be taken into account, yet which it is often exceedingly difficult to estimate, even roughly. These factors, in the case of the parasites of Australian sheep-flies, are very complex.

The most important of these factors is the accessibility of the host species to the parasite. If the parasite has relatively little opportunity of access, it cannot do much harm to the species as a whole. It may destroy large numbers of specimens of its host species, but the really important question, from an economic standpoint, is the ratio of the number destroyed to the number not available for attack. The relative importance of this factor will depend, therefore, partly on the habits of the host species and partly on that of the parasite. Unfortunately these habits are but scantily known at present.

A second important factor will be the capacity of the parasite for inhabiting a certain locality in sufficient numbers. This will depend partly on the presence or absence of necessary food or of enemies, and partly on climatic conditions.

A third important factor, and one which it is impossible to estimate in the laboratory, may be stated as follows :—Given

that a parasite will readily attack its host under laboratory conditions, will it do so on an extended scale where its host is accessible in large numbers? For example, *Australencyrtus giraulti* will attack maggots with great avidity in the laboratory, but it is not known whether it would do so if given the same opportunity on a large scale in nature. The only way to test this would be to liberate the parasite in numbers in a given district and see if it would establish itself.

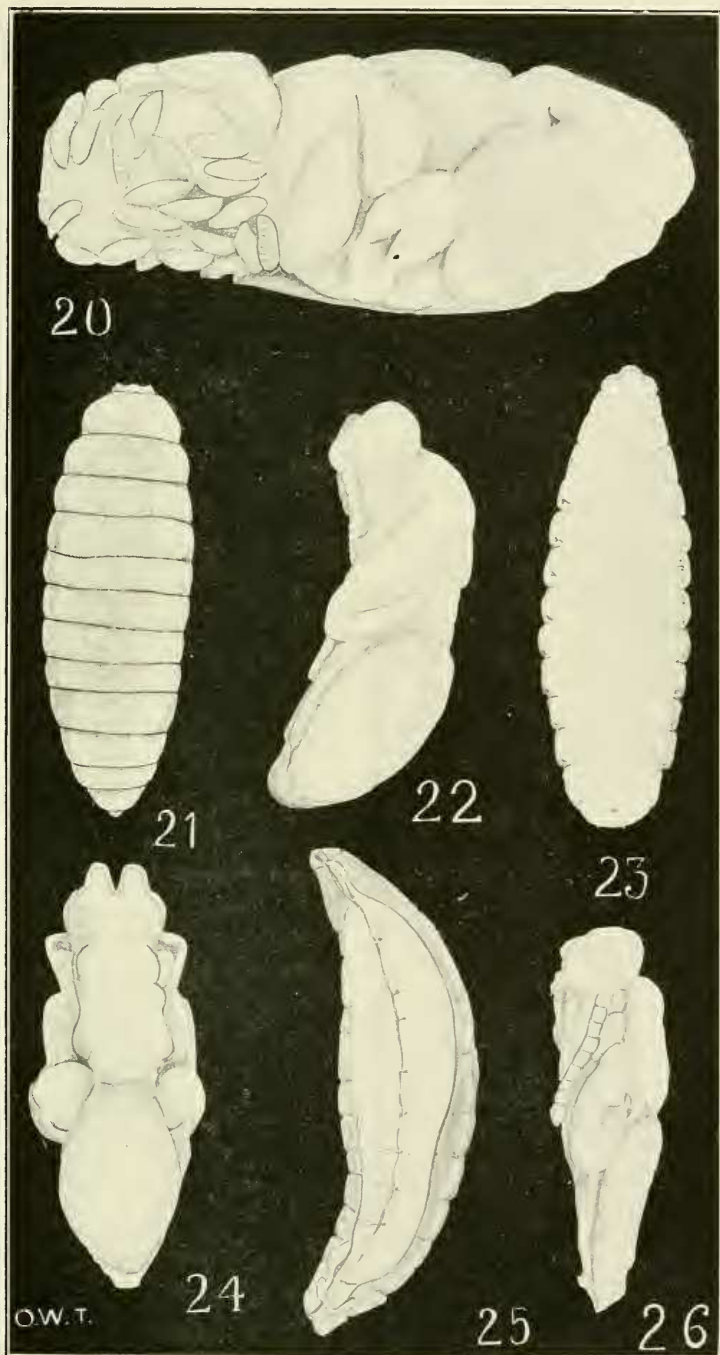
If any one of the factors be continuously unfavourable, then the parasite cannot be of any very great importance. If finally the parasite is to eradicate the host, not only would all these conditions have to be very favourable, but a fourth factor would have to be taken into account, i.e. the relative rate of breeding of host species and parasites. It will now be necessary to examine the effect of chalcid wasps on sheep-flies along these lines.

An immense amount of material for parasitizing is constantly available to these wasps; it follows, obviously, that any parasite which is not common can destroy only a very small percentage of the available larvæ or pupæ; if the available material, however great in amount, is small compared with what is not available, the economic importance of the parasite is practically nil. It seems, as will be shown below, that such is the case with those wasps which attack the fly-pupæ; and such forms as *Dirhinus sarcophage*, *Hemilexomyia abrupta*, *Pachycrepoideus dubius*, and *Paraspilomicrus froggatti* must be regarded as nothing more than entomologically interesting. Their scarcity probably depends on the unfavourable nature of the third factor, possibly also on the presence of enemies, or on poor food supply.

Spalangia muscidarum has been recorded as parasitizing various Muscid flies to a great extent in Eidsvold; it was also occasionally found destroying blowflies in Roma and in Brisbane, but there is as yet no evidence to show that it is of any more practical use against the sheep maggot-fly pest than such a form as *Dirhinus sarcophage*.

Of *Nasonia brevicornis* much has been hoped; by some it has been regarded as the ultimate means of actually eradicating, or at any rate controlling, the blowfly. Taking into consideration the above general remarks, it will be seen that these claims are founded on no very firm evidence. Even

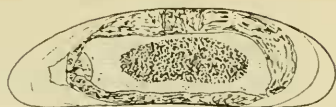
assuming that all the other factors are favourable (which is, however, not the case) it is evident that *Nasonia* cannot possibly act as an efficient control, since the blowflies breed not only faster but also more numerous. Suppose, for example, we liberated a single female *Nasonia* and a single gravid female blowfly, e.g. *Pycnosoma*, in a certain district in which neither occurred. The blowfly would lay about 250 eggs, all of which, it may be assumed, would possibly produce adults. Now *Nasonia* would parasitize these pupæ to such an extent that about 113 offspring would be produced by it—not at the expense of 113 blowflies however, but of only about 17 to 20, as already mentioned. *Nasonia*, in fact, would be a much more useful insect if it laid only one egg per pupa. Hence after the very first generation we would have 113 chalcids and about 230 blowflies; after the next few generations the difference would become very great, and if the flies had no other enemies they would soon overrun the country. Even if we contrast the period (*a*) which elapses between the deposition of eggs by the chalcid and oviposition by the females which emerge from such eggs (oviposition occurring within a few hours after emergence), with (*b*) that occupied by *Pycnosoma* from its deposition as an egg until the resulting female is capable of ovipositing, it appears that the above result will not be materially affected; since (*a*) the wasp period referred to, during midsummer in Brisbane, is about 14 days, whereas (*b*) in the case of the blowfly it is from 14 to 16 days distributed as follows—about 9 to 10 days in the immature stages (egg, larva, and pupa) and about 5 to 6 days after emergence before egg-laying takes place. As an effective control, then, *Nasonia* is of little value. To what extent, then, does it act as a check? This depends entirely upon the ratio of the number of pupæ to which it has access, to the number of those which it cannot harm. Simple experiments, such as enclosing a number of these chalcids in a jar in the bottom of which was a thin layer of soil containing pupæ, showed definitely that the wasps would not dig into the ground. It is necessary, therefore, to inquire as to the proportion of pupæ lying on the soil to those below it. The following simple experiments were carried out during the summer of 1920-21 in Brisbane, but it should be carefully noted that they were performed partly under laboratory conditions and partly under natural *local* conditions, but not under sheep-district conditions. It is reasonable to assume, therefore, that similar



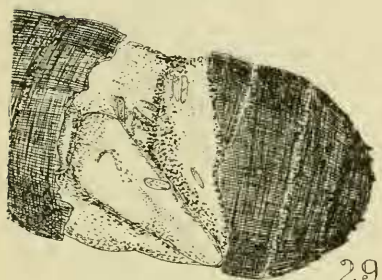
Figs. 20-22, *Nasonia brevicornis*. 20, blowfly nymph (*Lucilia*) showing clusters of *Nasonia* larvae two days old; 21, larva in "grey stage"; 22, pupa.—Figs. 23, 24, *Dirhinus sarcophagae*. 23, larva, seven days old, ventral view; 24, pupa, dorsal view.—Figs. 25, 26, *Australencyrtus giraulti*. 25, larva, lateral view, showing respiratory system; 26, pupa.



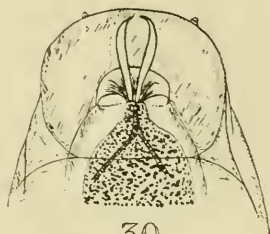
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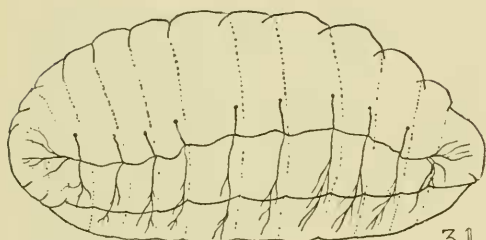
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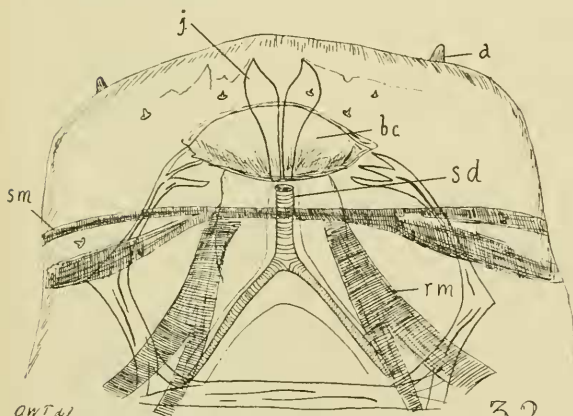
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31.



33.



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34.

Figs. 27-33, *Nasonia brevicornis*. 27, freshly deposited egg; 28, 18-hour embryo—note head, intestine, and anus; 29, blowfly pupa with a cluster of *Nasonia* eggs; 30, head-end of larva in first instar, ventral view showing jaws; 31, larva, three days after its deposition as an egg, second instar, showing respiratory system; 32, head of larva figured in fig. 31, showing jaws (*j*), antennæ (*a*), buccal cavity (*b.c.*), salivary duct (*s.d.*), sphincter muscle (*s.m.*), and retractor muscle (*r.m.*); 33, jaw of larva in third instar.—Fig. 34, egg of *Dirhinus sarcophagæ* from uterus of parent.

results will not necessarily be obtained in our Western areas as in Brisbane. It might be expected, for example, that maggots would pupate to a much larger extent in the wool, and beneath the carcass of a dead sheep (where they would be accessible to the chalcid), than they would in less protected places, such as under a piece of dry meat.¹ Experiments carried out with rather large surfaces, such as sheep's heads split down the centre to produce greater areas for protection, indicate that this does not make much difference. In view of the unfavourable results to be described, obtained locally with *Nasonia*, it seems at least worth while to repeat the experiments with various species of larvæ under sheep-country conditions during different portions of the year.

In January, 1921 (i.e. during the hottest part of the year), *Lucilia sericata* and *Sarcophaga* spp. were allowed to infect meat placed on dry soil. The experiment was carried out in the shade. After the maggots had ceased feeding the meat had to a great extent disappeared, only the fibrous portion remaining and producing an excellent shelter for pupating maggots. Different layers of the underlying soil were then removed and the pupæ in each layer counted, the following results being obtained :—

				<i>L. sericata.</i>	<i>Sarcophaga</i> spp.
Number of pupæ—					
On surface or partly exposed	..			105	2
To depth of $\frac{3}{4}$ in.	..	..	..	663	14
From $\frac{3}{4}$ to $2\frac{3}{4}$ in.	..	..	..	1,403	47
From $2\frac{3}{4}$ to $3\frac{1}{2}$ in.	..	..	..	172	4
From $3\frac{1}{2}$ to 5 in.	..	..	..	51	..
From 5 to 6 in.	..	..	..	7	..
Percentage on surface	..	..	..	4.37	3

¹ J. L. Froggatt (1919, p. 260) has stated that it is generally amongst the pupæ of *P. rufifacies* and to a less extent *P. varipes* that *Nasonia* is actually found to work in the field, this being due largely to the habits of the larvæ of these particular species, which usually pupate under the edge of the carcass remains or on the bones, wool, etc., instead of crawling away as the maggots of other blowflies do.

During February a sheep's head, split down the middle, was put into a box of dry soil, and infested entirely with *Pycnosoma rufifacies* and *P. varipes*. After about six days, the head was lifted and about 100 blowfly pupæ counted; as the experiment was intended for other purposes (as described below) the pupæ beneath the soil were not counted, but it is significant that after several days thousands of *Pycnosomas* hatched, the bottom of a box, 2 ft. by 1½ ft., being literally green with them.

In April results were obtained which seem to show the effect of heavy rain on pupation. The sheep's heads were placed in a box, and became duly infested with *Ophyra nigra*, *Sarcophaga* spp., *Pycnosoma rufifacies*, and *Lucilia sericata*. Heavy rain fell, the whole contents of the box becoming thoroughly wet. One portion of the box was more wet than the remainder; it contained no pupæ. No pupæ occurred on the surface anywhere in the box, but were all found at a depth of from $\frac{3}{4}$ to 1 inch below the surface where the soil was least wet. Below this the soil was wetter, and only six pupæ were discovered in it, but in the relatively drier region above this level several hundred were counted. As several thousand pupæ had been expected a search was made in the soil surrounding the box, and as a result great accumulations of pupæ of all the species were found *buried in the soil to the depth of one inch* under sheltering boards close beside the box. Unprotected soil to a distance of 5 feet from the box was examined and showed the presence of numerous fly-pupæ. It would seem, therefore, that during rainy weather the conditions for *Nasonia* are even more unfavourable, since, though the maggots do not bury themselves so far down in the soil, *none pupate on the surface*. If these experiments are confirmed under sheep-country conditions, then this chalcid cannot be regarded as even a serious check on the spread of sheep blowflies.

These experiments do not take account of another serious deficiency on the part of *Nasonia*, viz., the alleged inactivity of the parasite at the very time that the flies are at their worst (Report of Blowfly Committee, Institute of Science and Industry, December, 1920).² Possibly this is accounted for by

² As this pamphlet is not readily available to workers, we deem it advisable to republish the statements relating to the work of *Nasonia* at Mr. W. Russell's sheep station, Dalmally, near Roma, Queensland:—
"As occasionally over 80 per cent. of the blowfly pupæ are found to be

the following facts :—Increased fly activity generally means a decrease in the length of the life-cycle (especially the immature stages, owing to favourable conditions of temperature and moisture) and incidentally of the pupal period. For *Pycnosoma rufifacies* and *P. varipes* this latter period is $4\frac{1}{2}$ days during the summer months, becoming as low as 3 days (on an average 4 days) during the most favourable weather (February).³ The egg period of *Nasonia* in Brisbane during this time is 40 hours. It follows that, of these 3 or 4 days which the fly passes in the pupal stage and during which the chalcid can act against the fly, nearly two days are occupied in the hatching of the parasite's egg. Hence, unless the pupæ are attacked within 24 to 30 hours after pupation, they are practically safe from destruction by *Nasonia*; indeed, we have the paradoxical conception of the pupæ of *Pycnosoma*, during this period, acting as a most efficient chalcid-destroyer—in other words, as a “*Nasonia*-trap,” in that at least half the chalcid eggs deposited must be wasted, unless, of course, the wasp will instinctively refuse to oviposit in advanced pupæ.⁴ The immunity of *Pycnosoma* to *Nasonia* attack was exhibited by the following experiment, carried out in February, 1921, when *Pycnosoma* spp. are the dominating blowflies in Brisbane. A split sheep's head was placed in a box of soil and allowed to

killed by this parasite, it should have a marked effect in controlling the increase of the flies, but unfortunately the Chalcid Wasp seems to be dormant at the very time the flies are worst. Very much has yet to be learned of the life-history of both flies and parasites. This tends to show that although it must be a check, yet it cannot in the light of present knowledge be classed as an overwhelming check. At Dalmally, in the height of the attack of the present year, Chalcids were not to be found. Then at the end of September they began to show in the breeding cages and are now (December, 1920) breeding in big numbers. Even if the Chalcids be responsible for the abatement of the fly trouble since October, it was quiescent when the principal losses in sheep occurred. We conclude therefore that while Chalcids are certainly a check, they are not, in the light of our present knowledge, important enough to supersede the jetting process.”

³ J. F. Illingworth in an article. “The Australian Sheep Fly in Hawaii” (Proc. Ent. Soc. Hawaii, 1917 (1918), 3, p. 429; Abstr. in Rev. Appl. Ent., B., 6, p. 163) referred to the rapid development there during July. A dead animal was exposed on 16th July, larvæ hatched out next morning, and three days later entered the soil to pupate, the pupal stage occupying about six days.

⁴ Altson (1920, p. 224) states that *Nasonia* shows preference for pupæ between 24 and 72 hours old for oviposition. We have found that the wasp will readily oviposit in living blowfly pupæ of any age.

become heavily infested with these two species. When the maggots had begun to pupate the box was closed by a "wasp-proof" gauze, and 250 *Nasonias* liberated in the box. The wasps could perhaps scarcely have had a better opportunity for demonstrating their action on pupæ buried in the soil, as well as on recently pupated *Pycnosoma* pupæ. As stated above, about a hundred pupæ were found beneath the sheep's head, but the result of the experiment showed that several thousand had entered the soil. *Pycnosomas* hatched in due course in immense numbers. Thirteen days later *twelve Nasonias* hatched, probably all from one unfortunate pupa! Here, under the best conditions, except that they were in captivity (which does not seem to make much difference with *Nasonia*), the wasps were helpless in the face of a reduced pupal period on the part of their host-fly. It is at least possible that these facts will account for the field observations above quoted.

If these laboratory experiments can be confirmed in the field, it is evident that little can be hoped from such wasps as oviposit in pupæ. Parasites which attack the larvæ should be much more useful, since they can obtain access to all the individuals that the former class can, as well as many that the former cannot. To this group belong *Chalcis* spp. and *Australencyrtus giraulti*. The former can probably be dismissed on account of their rarity, though of course they might be bred up in the laboratory. The latter is more hopeful, as it appears to be fairly common in Brisbane and breeds very easily, but has, unfortunately, a rather long developmental period. The first factor, namely, access to its host, is very favourable; of the others, however, nothing is known, and it might turn out quite useless in the field. We hope to distribute a large number later in the year in the hope that this Encyrtid may be of some use.

To this latter group of maggot attackers belongs also an English Braconid species, *Alysia manducator*. This has all the advantages possessed by the above-mentioned maggot-parasitizing wasps, and has also the additional qualification of laying a very large number of eggs and distributing them among an equal number of maggots. A wasp living under English conditions might be unable to exist in the Australian climate; but, on the other hand, it might be stimulated to greater activity, and it is certainly a parasite well worth

attempting to introduce into Australia provided that it is not already known to parasitize useful insects (Graham-Smith, 1916, 1919; Johnston and Bancroft, 1920; Altson, 1920).

Table showing Parasites and Hosts in Australia.

The following table may be of interest. It is not unlikely that all the parasites mentioned may prove to be able to attack all the species of flies in the list. The introduced English blowfly, *Calliphora erythrocephala*, does not occur in Queensland as far as we are aware, though Froggatt has reported its presence in Sydney.

Australian Muscoid Flies.	PARASITES.							
	<i>Nasonia brevicornis</i> .	<i>Paraspilomicrus froggatti</i> .	<i>Spalangia muscidarum</i> .	<i>Dirhinus sarcophage</i> .	<i>Pachycrepoides dubius</i> .	<i>Hemitecomyia abrupta</i> .	<i>Chalris calliphoræ</i> .	<i>Australencyrtus giraulti</i> .
<i>Chrysomyia rufifacies</i> ⁵ ..	×	..	×	×	..	..	..	×
<i>Microcalliphora varipes</i> ..	×	..	×	×	..	..	..	×
<i>Lucilia sericata</i> ..	×	..	..	×	..	..	..	×
<i>Lucilia</i> spp. ..	×	×	×	×	..	..	..	×
<i>Ophyra nigra</i> ..	×	..	..	..	..	×	..	..
<i>Chrysomyia dux</i> ..	..	..	×	..	..	..	..	×
<i>Paracalliphora augur</i> ..	×	..	×	..	..	..	×	..
<i>Pollenia stygia</i> ..	×	..	×	..	..	×	..	..
<i>Calliphora erythrocephala</i> ..	×	..	..	..	..	..	..	..
<i>Sarcophaga irrequieta</i> ..	×	..	×	×	..	..	..	..
<i>Sarcophaga aurifrons</i> ..	×	..	×	×	..	..	..	×
<i>Sarcophaga misera</i> ..	×	..	×	..	..	..	..	..
<i>Sarcophaga impatiens</i> ..	×	..	×	×	..	..	..	..
<i>Sarcophaga</i> spp. ..	×	..	×	×	..	..	..	×
<i>Musca domestica</i> ..	×	..	×	..	?	×	..	..
<i>Musca</i> spp. ..	×	..	×	..	..	..	..	..
<i>Stomoxys calcitrans</i> ..	..	..	×	..	..	..	..	..

C.—DESCRIPTIONS OF NEW HYMENOPTEROUS PARASITES OF AUSTRALIAN BLOWFLIES.

Australencyrtus giraulti n. gen., n. sp. (Encyrtidæ).

(Figs. 1, 9, 11-17, 25, 26.)

Description of Female.

Length of moderate-sized specimens 1.6 to 1.92 mm. Small individuals may be much shorter, measuring little over

⁵ The first two species are referred to in the rest of this paper under the genus *Pynosoma* as they are generally known by such name in Australia. According to a recent remark by Mr. W. W. Froggatt, the correct name for *C. rufifacies* is *C. albiceps* Wied. (P.L.S., N.S.W., 1920, p. 472).

1.2 mm. in length. All measurements given below refer to a large form 1.8 mm. long. The wasp is easily recognised by its shiny-black upper surface and pale-brown under surface (figs. 1, 11).

Head (fig. 13).—Height .6 mm.; breadth .5 mm.; length .32 mm. Depth of eyes about half that of head. Distance of ventral portion of eyes to mouth twice that of dorsal part to vertex. Head shiny black with very faint reticulate pattern; the numerous bristles generally lodged in small depressions. Ocelli large and prominent, nearer to eyes than to one another. Frons with a deep depression. Clypeus gently convex. Insertion of antennæ on a level with lowest part of eyes; their distance from one another equal to their distance from the eyes.

Eyes bare; about fourteen bristles immediately around orbit; two vertical bristles in line with posterior ocelli. Front with about fifty other bristles.

Mandibles shiny black, long (.216 mm.) and prominent, tridentate, the anterior tooth very small; the middle one larger and prominent, the lowest somewhat smaller; all very obtuse (fig. 14). Mandibles provided with twelve bristles. Maxilla short, foliaceous, covered with about twenty hairs on upper surface. Palps pale brown, long and prominent, last joint especially large. Submentum not prominent; the mentum somewhat triangular and provided with a row of short bristles. Labial palps rather small, with three joints of which the second is the smallest. Mentum with prominent but short ridges.

Length of antennæ .88 mm.; maximum breadth .06 mm. Ten joints including ring-joint. Scape slender, about .25 mm. in length, slightly broader at tip than at base, moderately bristly, brown. Pedicel about one-third length of scape, very conical. Ring-joint very indistinct, about .02 mm. long. The following six joints very dark brown and heavily clad with short bristles; the proximal one oval, the others gradually shortening, the most distal dome-shaped. Club 3-jointed. .16 mm. in length (fig. 12).

“*Thorax*.”—Shiny black above, light brown below: pronotum prominent, length about half that of head; with delicate transverse striations. Mesothorax about thrice the length of pronotum; as the anterior part of the pronotum projects into the posterior concavity of head, and also is longer at the sides than dorsally, the mesothorax appears, in dorsal

view, nearly six times the length of the pronotum. Scutellum very prominent, about two-thirds the length of scutum. Scutum distinctly ridged; pronotum faintly striated; scutellum smooth. In the middle of the scutellum on either side of the mid-line, the chitinous plate has a pair of small circular holes. The ventral side of thorax light brown, shiny. From the postero-ventral region of the pronotum a thin plate, pale brown in colour and rather transparent, is given off backwardly, reaching so far back as to overlap the tegulæ ventrally. Probably the anterior spiracle lies beneath this plate; a similar structure is developed along the whole of the ventral portion of the mesonotum, and overlaps a portion of the last coxa; it is light brown in colour, much stronger than the similar extension from the pronotum, and appears to be hollow. The second spiracle is probably hidden beneath this structure. From the metathorax a similar overlapping structure is developed, but it is much smaller. Immediately behind it lies the third spiracle; just above it is a small cluster of silvery hairs. Pronotum with a row of 18 short (9 and 9), scutum with 56 (28-28) rather long bristles; scutellum with 22 (11-11) moderately long bristles on anterior half, a pair on the border, three-quarters the distance to distal end, and a pair of rather long scutellar apicals. Tegulæ each with three bristles.

Legs brown.—First leg: Coxa largest, powerful; breadth half the length; thirteen bristles externally, and two rows of small bristles on posterior (inner) margin. Trochanter half the length of coxa; double-jointed; hairless. Femur rather short, twice the length of coxa and thick-set; with four rows of moderately long bristles. Tibia one and a half times the length of coxa, slightly broader distally than proximally; spur as long as that of second leg, but considerably weaker, with five rows of moderately long bristles. Tarsus nearly as long as femur, the five joints very hairy; claws not markedly large.—Second leg: Coxa longer but less stout than in first leg; provided with six longitudinal rows of bristles. Trochanter long, double-jointed, hairless. Femur as long as first femur, but rather weaker; with six longitudinal rows of bristles. Tibia long (.56 mm.), thinner than femur; with five rows of bristles, the enlarged tibial spur very faintly serrated at its inner distal end. First tarsal joint much elongated; claws small.—Third leg: Coxa exceedingly stout, a little longer than broad, with a faint reticulation; six rows of short bristles.

Trochanter single-jointed and with five rows of bristles. Femur about as long as first, but bulging strongly in middle, with six rows of bristles. Tibia a little shorter than second; bristly; first tibial joint much elongated, claws small.

Wings (fig. 15).—Fore wings: Length 1.44 mm., breadth .77 mm. Submarginal: marginal: post-marginal: stigmal = 37:5:6:8. Length of submarginal .59 mm. Submarginal with fourteen large bristles, those in middle of vein the largest. Marginal and post-marginal with three rows of rather shorter bristles. Stigmal with eight bristles; its termination broadened, angular, hooked and bluntly pointed, 4-punctate as figured. Anterior border strongly ciliated. Whole wing ciliated, except posterior border and a small area anterior to this.—Hind wings: Length .96 mm., breadth .32 mm. The distal marginal part of the wing-vein .3 mm. long; the distal submarginal portion very slightly longer and rather transparent, and with two punctures. A row of eleven bristles immediately anterior to it. Wing ciliated, except for a clear area at base of wing.

Abdomen shining black, marked with a delicate reticulum. Rather broader than thorax, and dorsoventrally compressed. First tergite as long as the next two together. Second, third, and fourth tergites all about equal in length. Fifth rather longer, and partly overlapping the more anterior ones, being very concave in dorsal view. First tergite with five pairs of bristles laterally; sternum with very numerous short bristles, and three pairs of longer bristles posteriorly. Second tergite with a transverse row of seven moderately large bristles on either side; five pairs on sternum. Third tergite with a transverse row of seven bristles on either side and a very long bristle laterally; three pairs on sternum. Fourth tergite with a row of six bristles on either side; sternum with a group of eight pairs. The fifth tergite very bristly; anteriorly a row of four bristles on either side; posterior to these a row of five larger bristles; a marginal row of twelve bristles on either side; the most anterior part of the tergite with a small rounded thickened chitinous area bearing five large bristles. Sternum with five pairs of bristles. The termination of the ovipositor provided with a marginal row of ten bristles. Point of ovipositor sharp; no serrations present; length .45 mm.; free posterior part of sheath .16 mm.

Description of Male.

The male closely resembles the female in general appearance and size. It differs in the following characters :—

Length of antenna (fig. 12) greater, being about 1.2 mm. ; scape very slightly shorter than in female, measuring about .24 mm. in length ; next joint, corresponding to the pedicel, very short, .08 mm. in length ; third joint .16 mm. in length. The following seven joints about equal in length, measuring .096 mm. ; the most distal joint not club-shaped, but somewhat conical with apex of cone distally, without any sign of division into three parts such as occurs in female. Length of mandibles about the same as in female ; teeth slightly more acute.

Thorax as in female. First coxa shaped as in female ; seven large marginal bristles, ten smaller externally, numerous minute bristles internally. Trochanter single-jointed, two bristles on dorsal distal end. Femur with three rows of bristles, and an indication of a fourth row. Second trochanter very short, single-jointed, hairless. Bristles of second femur weak. Tibial spur weaker than in female.

Wings as in female, except that the stigmal vein is very slightly shorter, the termination a little more hammer-shaped. Size exactly as in female.

The third abdominal segment bears ventro-laterally a very long bristle, even longer than in female. The penis is rather long, about equal in length to the terminal part of the ovipositor of female.

The biology of this little wasp has been described in an earlier part of this paper, the various immature stages being figured (figs. 9, 16, 17, 25, 26).

Systematically the insect belongs to the Chalcidoid family Encyrtidae, sub-family Encyrtinae, tribe Mirini of Ashmead, or Encyrtini (as considered by Girault, 1915). It does not fall into any of the genera as given in either Ashmead's or Girault's keys. We therefore propose to establish for its reception a new genus, *Australencyrtus*, with *A. giraulti* as type. Mr. A. A. Girault, the well-known authority on chalcid wasps, informs us that it comes near Perkins's genus *Echthrogonartopus*. It differs from that genus, however, chiefly in that the club is distinctly shorter than the funicle ; the frontal region between

the eyes is considerably wider than the width of eyes, and the scutellum is not sculptured; while the post-marginal vein is very slightly shorter than stigmal.

Type specimens (allotype and holotype) deposited in the Queensland Museum, Brisbane. Bred from various blowfly pupæ in Brisbane.

Paraspilomicrus froggatti n. gen., n. sp. (Proctotrypoidea—Family Diapriidæ). (Figs. 4, 8, 18, 19.)

Description of Male.

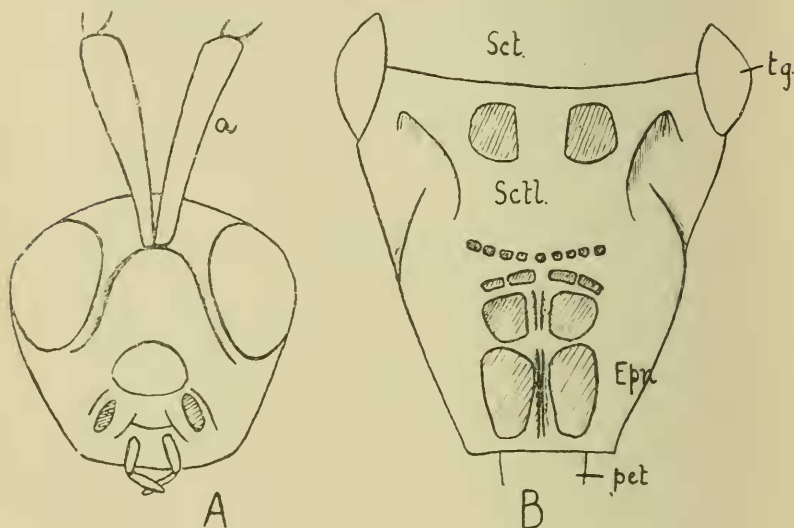
Length 1.7 mm. (excluding antennæ); shining black.

Head.—Length .34 mm.; height .45 mm.; breadth .37 mm. Frons not protruding in front of eye. Eye rather small, bare, distant its own height from mouth; depth less than half the height of head. Ocelli very prominent, as near to each other as to eyes. Head smooth, shiny black, without pattern, with numerous short bristles. Antennæ (fig. 18) inserted on a marked prominence; very long (1.15 mm.), consisting of thirteen joints; scape .32 mm. long; pedicel and next two joints about equal (.08 mm.); remaining joints shorter, broader, and rounded, last elongated and conical, the whole covered with numerous rather short bristles. Palps long, brown, terminal segments slightly longer than sub-terminal; both bearing six setæ.

Thorax.—Length two and a half times the breadth. Tegulæ very prominent, forming large angular prominences at sides. Pronotal neck short, with longitudinal shallow excavations; pronotum itself hardly visible from above. Scutum smooth, shiny black, without any pattern; parapsidal furrows very prominent; rather wider than long; with a small number of moderately long, brown reclinate bristles, developing into a more pronounced growth laterally just behind pronotum. Scutellum four-fifths length of scutum, with a light growth of hairs; a pair of large square depressions on either side of mid-line, just behind scutum; and a transverse row of nine small rounded depressions crossing the scutellum two-thirds the distance from anterior end. Behind these, a row of four larger rectangular depressions. Epinotum with a complete median longitudinal carina; with four irregular ridged depressions laterally. Petiole with a complete median carina and two pairs of longitudinal depressions on either side, more

distinct in anterior half; provided laterally with rather long, somewhat curled hairs. Epinotum sculptured laterally and with a growth of short silvery hairs. Scutum and scutellum quite bare and smooth at sides. Pronotum with a growth of hairs laterally along posterior margin. Thorax lightly hairy beneath.

Paraspilomicrus froggatti.



Text-fig. A, Face-view.

B, Dorsal view of posterior end of thorax.

Epn., epinotum; *pet.*, petiole; *sct.*, scutum; *sctl.*, scutellum; *tg.*, tegula. Shaded portions represent depressions. Only first joint of antenna (*a*) showing in Fig. A.

Legs.—Coxæ dark brown, hairy, short and stout, especially the third. Second coxa weaker than the others. Trochanters very long and slender. Femora long, hairy; proximal half narrow, distal half expanded to become markedly club-shaped; proximal portion light brown, distal very dark brown, nearly black. First and second tibiæ rather shorter, dark brown, hairy, provided distally with two moderately long setæ; last tibia considerably longer, and with a distinct tibial spur. Tarsi five-jointed, moderately long; last very long; all hairy, but not markedly so; claws short.

Wings.—Length of fore wing (fig. 19) 1.6 mm.; breadth .64 mm.; submarginal vein .64 mm. long; marginal vein very thick and short, .064 mm. long, with six long bristles;